

CLAIMS

What is claimed is:

1. A magnetic element comprising:

a pinned layer, the pinned layer being ferromagnetic and having a first
5 magnetization;

a current confined layer having at least one channel in an insulating matrix, the at
least one channel being conductive and extending through the current confined layer; and

a free layer, the free layer being ferromagnetic and having a second magnetization,
the current confined layer residing between the pinned layer and the free layer;

10 wherein the pinned layer, the free layer, and the current confined layer are
configured to allow the second magnetization of the free layer to be switched using spin
transfer.

2. The magnetic element of claim 1 wherein the at least one channel has a
15 diameter of between one and three nanometers.

3. The magnetic element of claim 1 wherein the magnetic element further
includes:

a second pinned layer being ferromagnetic and having a third magnetization;

20 a nonmagnetic spacer layer residing between the free layer and the second pinned
layer.

4. The magnetic element of claim 3 wherein the nonmagnetic spacer layer includes a second current confined layer.

5. The magnetic element of claim 3 wherein the nonmagnetic spacer layer includes a barrier layer, the barrier layer being insulating and having a thickness that allows tunneling of current carriers between the free layer and the second pinned layer.

6. The magnetic element of claim 3 wherein the nonmagnetic spacer layer includes a conducting layer.

7. The magnetic element of claim 1 wherein the free layer is a synthetic free layer including a first ferromagnetic layer and a second ferromagnetic layer separated by a nonmagnetic layer.

8. The magnetic element of claim 1 wherein the current confined layer further includes:

a first conductive layer disposed between the free layer and the current confined layer; and

a second conductive layer disposed between the pinned layer and the current confined layer.

9. A magnetic element comprising:

a first pinned layer, the first pinned layer being ferromagnetic and having a first magnetization;

a current confined layer having at least one channel in an insulating matrix, the at least one channel being conductive and extending through the current confined layer; and

5 a first free layer, the first free layer being ferromagnetic and having a second magnetization, the current confined layer residing between the first pinned layer and the first free layer; and

a spin tunneling junction having a second free layer, a second pinned layer and a barrier layer residing between the second free layer and the second pinned layer, the barrier
10 layer being insulating and having a thickness that allows tunneling of current carriers between the second free layer and the second pinned layer, the second free layer and the first free layer being magnetostatically coupled;

wherein the first pinned layer, the first free layer, and the current confined layer are configured to allow the second magnetization of the first free layer to be switched using spin
15 transfer.

10. The magnetic element of claim 9 wherein the at least one channel has a diameter of between one and three nanometers.

20 11. The magnetic element of claim 9 further comprising:
a separation layer between the first free layer and the second free layer, the separation layer for insuring that the first free layer and the second free layer are magnetostatically coupled.

12. The magnetic element of claim 9 wherein the spin tunneling junction is a dual spin tunneling junction having a third pinned layer and a second barrier layer residing between the third pinned layer and the second free layer, the third pinned layer being ferromagnetic.

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13. The magnetic element of claim 12 further comprising:

a fourth pinned layer; and

a nonmagnetic spacer layer, the nonmagnetic spacer layer residing between the first free layer and the fourth pinned layer, the second free layer and the first free layer being spaced apart such that the first free layer and the second free layer are antiferromagnetically coupled.

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14. The magnetic element of claim 9 wherein the magnetic element is shaped such that the first free layer has a first width and the second free layer has a second width, the second width being greater than the first width.

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15. The magnetic element of claim 9 wherein the current confined layer further includes:

a first conductive layer disposed between the first free layer and the current confined layer; and

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a second conductive layer disposed between the first pinned layer and the current confined layer.

16. A magnetic element comprising:

a first pinned layer, the first pinned layer being ferromagnetic and having a first magnetization;

a current confined layer having at least one channel in an insulating matrix, the at least one channel being conductive and extending through the current confined layer; and

a first free layer, the first free layer being ferromagnetic and having a second magnetization, the current confined layer residing between the first pinned layer and the free layer; and

a spin valve having a second free layer, a second pinned layer and a nonmagnetic spacer layer residing between the second free layer and the second pinned layer;

wherein the first pinned layer, the first free layer, and the current confined layer are configured to allow the second magnetization of the first free layer to be switched using spin transfer.

17. The magnetic element of claim 16 wherein the nonmagnetic spacer layer is a second current confined layer having at least a second channel in a second insulating matrix, the at least the second channel being conductive and extending through the second current confined layer.

18. The magnetic element of claim 16 further comprising:

a separation layer between the first free layer and the second free layer, the separation layer for insuring that the first free layer and the second free layer are magnetostatically coupled.

19. The magnetic element of claim 16 wherein the spin valve is a dual spin valve having a third pinned layer and a second nonmagnetic spacer layer residing between the third pinned layer and the second free layer, the third pinned layer being ferromagnetic.

5 20. The magnetic element of claim 19 further comprising:
a fourth pinned layer; and
a second nonmagnetic spacer layer, the second nonmagnetic spacer layer residing between the first free layer and the fourth pinned layer, the second free layer and the first free layer being spaced apart such that the first free layer and the second free layer are
10 antiferromagnetically coupled.

21. The magnetic element of claim 20 wherein the second nonmagnetic spacer layer includes a second current confined layer having at least a second channel in a second insulating matrix, the at least the second channel being conductive and extending through
15 the second current confined layer.

22. The magnetic element of claim 20 wherein the current confined layer further includes:

a first conductive layer disposed between the first free layer and the current confined layer; and
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a second conductive layer disposed between the first pinned layer and the current confined layer.

23. The magnetic element of claim 16 wherein the at least one channel has a diameter of between one and three nanometers.

24. A magnetic element comprising:

5 a first pinned layer, the first pinned layer being ferromagnetic and having a first magnetization;

a current confined layer having at least one channel in an insulating matrix, the at least one channel being conductive and extending through the current confined layer; and

10 a first free layer, the first free layer being ferromagnetic and having a second magnetization, the current confined layer residing between the first pinned layer and the first free layer; and

15 a dual spin valve/tunnel structure having a second pinned layer, a nonmagnetic spacer layer, a second free layer, a third pinned layer and a barrier layer residing between the second free layer and the third pinned layer, the barrier layer being insulating and having a thickness that allows tunneling of current carriers between the second free layer and the second pinned layer, the nonmagnetic spacer residing between the second pinned layer and the second free layer, the second free layer and the first free layer being magnetostatically coupled;

20 wherein the first pinned layer, the first free layer, and the current confined layer are configured to allow the second magnetization of the free layer to be switched using spin transfer.

25. The magnetic element of claim 24 further comprising:

a separation layer between the first free layer and the second free layer, the separation layer for insuring that the first free layer and the second free layer are magnetostatically coupled.

5 26. The magnetic element of claim 25 further comprising:

a fourth pinned layer; and

a second nonmagnetic spacer layer, the second nonmagnetic spacer layer residing between the first free layer and the fourth pinned layer, the second free layer and the first free layer being spaced apart such that the first free layer and the second free layer are
10 antiferromagnetically coupled.

27. The magnetic element of claim 26 wherein the second nonmagnetic spacer layer includes a second current confined layer having at least a second channel in a second insulating matrix, the at least the second channel being conductive and extending through
15 the second current confined layer.

28. The magnetic element of claim 24 wherein the nonmagnetic spacer layer is a second current confined layer including at least a second channel in a second insulating matrix, the at least the second channel being conductive and passing through the second
20 current confined layer.

29. The magnetic element of claim 24 wherein the current confined layer further includes:

a first conductive layer disposed between the first free layer and the current confined layer; and

a second conductive layer disposed between the first pinned layer and the current confined layer.

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30. The magnetic element of claim 24 wherein the at least one channel has a diameter of between one and three nanometers.

31. A method for providing a magnetic element comprising the steps of:

10 providing a pinned layer, the pinned layer being ferromagnetic and having a first magnetization;

providing a current confined layer having at least one channel in an insulating matrix, the at least one channel being conductive and extending through the current confined layer; and

15 providing a free layer, the free layer being ferromagnetic and having a second magnetization, the current confined layer residing between the pinned layer and the free layer;

wherein the pinned layer, the free layer, and the current confined layer are configured to allow the second magnetization of the free layer to be switched using spin transfer.

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32. The method of claim 31 further comprising the steps of:

providing a second pinned layer being ferromagnetic and having a third magnetization;

providing a nonmagnetic spacer layer residing between the free layer and the second pinned layer.

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33. The method of claim 31 wherein the current confined layer providing step further includes steps of:

providing a first conductive layer disposed between the free layer and the current confined layer; and

10 providing a second conductive layer disposed between the pinned layer and the current confined layer.

34. The method of claim 31 wherein the current confined layer providing step further includes the steps of:

15 providing at least one conducting layer;

providing at least one insulating layer, the at least one insulating layer alternating with the at least one conducting layer; and

providing a second conducting layer such that each of the at least one insulating layer is sandwiched between a conducting layer of the at least one conducting layer and/or
20 the second conducting layer;

the at least one conducting channel being formed from the at least one conducting layer and the second conducting layer and the insulating matrix being formed from the at least one insulating layer.

35. The method of claim 31 wherein the current confined layer providing step further includes the steps of:

annealing the magnetic element.

5 36. The method of claim 31 wherein the current confined layer providing step further includes the steps of:

co-depositing at least one conductive material with at least one insulating matrix material, the at least one conducting channel being formed from the at least one conductive material and the insulating matrix being formed from the at least one insulating matrix
10 material.

37. The method of claim 31 wherein the current confined layer providing step further includes the steps of:

forming the current confined layer using dry self-assembly.

15 38. The method of claim 31 further comprising the steps of:

providing a spin tunneling junction having a second free layer, a second pinned layer and a barrier layer residing between the second free layer and the second pinned layer, the barrier layer being insulating and having a thickness that allows tunneling of current carriers
20 between the second free layer and the second pinned layer, the second free layer and the free layer being magnetostatically coupled.

39. The method of claim 38 further comprising the step of:

providing a separation layer between the free layer and the second free layer, the separation layer for insuring that the free layer and the second free layer are magnetostatically coupled.

5 40. The method of claim 38 wherein the spin tunneling junction is a dual spin tunneling junction and wherein the spin tunneling junction providing step further includes the steps of:

 providing a third pinned layer, the third pinned layer being ferromagnetic;

 providing a second barrier layer residing between the third pinned layer and the
10 second free layer.

 41. The method of claim 40 further comprising the steps of:

 providing a fourth pinned layer; and

 providing a nonmagnetic spacer layer, the nonmagnetic spacer layer residing
15 between the free layer and the fourth pinned layer, the second free layer and the free layer being spaced apart such that the free layer and the second free layer are antiferromagnetically coupled.

 42. The method of claim 38 further comprising the step of:

20 shaping the magnetic element such that the free layer has a first width and the second free layer has a second width, the second width being greater than the first width.

 43. The method of claim 31 further comprising the steps of:

providing a spin valve having a second free layer, a second pinned layer and a nonmagnetic spacer layer residing between the second free layer and the second pinned layer;

wherein the first pinned layer, the free layer, and the current confined layer are configured to allow the second magnetization of the free layer to be switched using spin transfer.

44. The method of claim 43 wherein the nonmagnetic spacer layer is a second current confined layer having at least a second channel in a second insulating matrix, the at least the second channel being conductive and extending through the second current confined layer.

45. The method of claim 43 further comprising the step of:
providing a separation layer between the free layer and the second free layer, the separation layer for insuring that the free layer and the second free layer are magnetostatically coupled.

46. The method of claim 43 wherein the spin valve is a dual spin valve and wherein the spin valve providing step further includes the steps of:
providing a third pinned layer, the third pinned layer being ferromagnetic; and
providing a second nonmagnetic spacer layer residing between the third pinned layer and the second free layer.

47. The method of claim 46 further comprising the steps of:

providing a fourth pinned layer; and

providing a second nonmagnetic spacer layer, the second nonmagnetic spacer layer residing between the free layer and the fourth pinned layer, the second free layer and the free layer being spaced apart such that the free layer and the second free layer are antiferromagnetically coupled.

48. The method of claim 47 wherein the second nonmagnetic spacer layer

includes a second current confined layer having at least a second channel in a second insulating matrix, the at least the second channel being conductive and extending through the second current confined layer.

49. The method of claim 31 further comprising the step of:

providing a dual spin valve/tunnel structure having a second pinned layer, a nonmagnetic spacer layer, a second free layer, a third pinned layer and a barrier layer residing between the second free layer and the third pinned layer, the barrier layer being insulating and having a thickness that allows tunneling of current carriers between the second free layer and the second pinned layer, the nonmagnetic spacer layer residing between the second pinned layer and the second free layer, the second free layer and the free layer being magnetostatically coupled.

50. The method of claim 49 further comprising the step of:

providing a separation layer between the free layer and the second free layer, the separation layer for insuring that the free layer and the second free layer are magnetostatically coupled.

5 51. The method of claim 50 further comprising the steps of:
providing a fourth pinned layer; and
providing a second nonmagnetic spacer layer, the second nonmagnetic spacer layer
residing between the free layer and the fourth pinned layer, the second free layer and the free
layer being spaced apart such that the free layer and the second free layer are
10 antiferromagnetically coupled.

 52. The method of claim 51 wherein the second nonmagnetic spacer layer
includes a second current confined layer having at least a second channel in a second
insulating matrix, the at least the second channel being conductive and extending through
15 the second current confined layer.

 53. The method of claim 45 wherein the nonmagnetic spacer layer is a second
current confined layer including at least a second channel in a second insulating matrix, the
at least the second channel being conductive and passing through the second current
20 confined layer.